

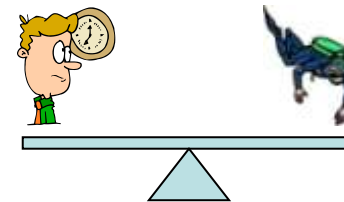
# **“Enabling SOA through Semantic Web Technologies”**

**SOA Symposium, Arlington, VA  
21-22 April 2010**

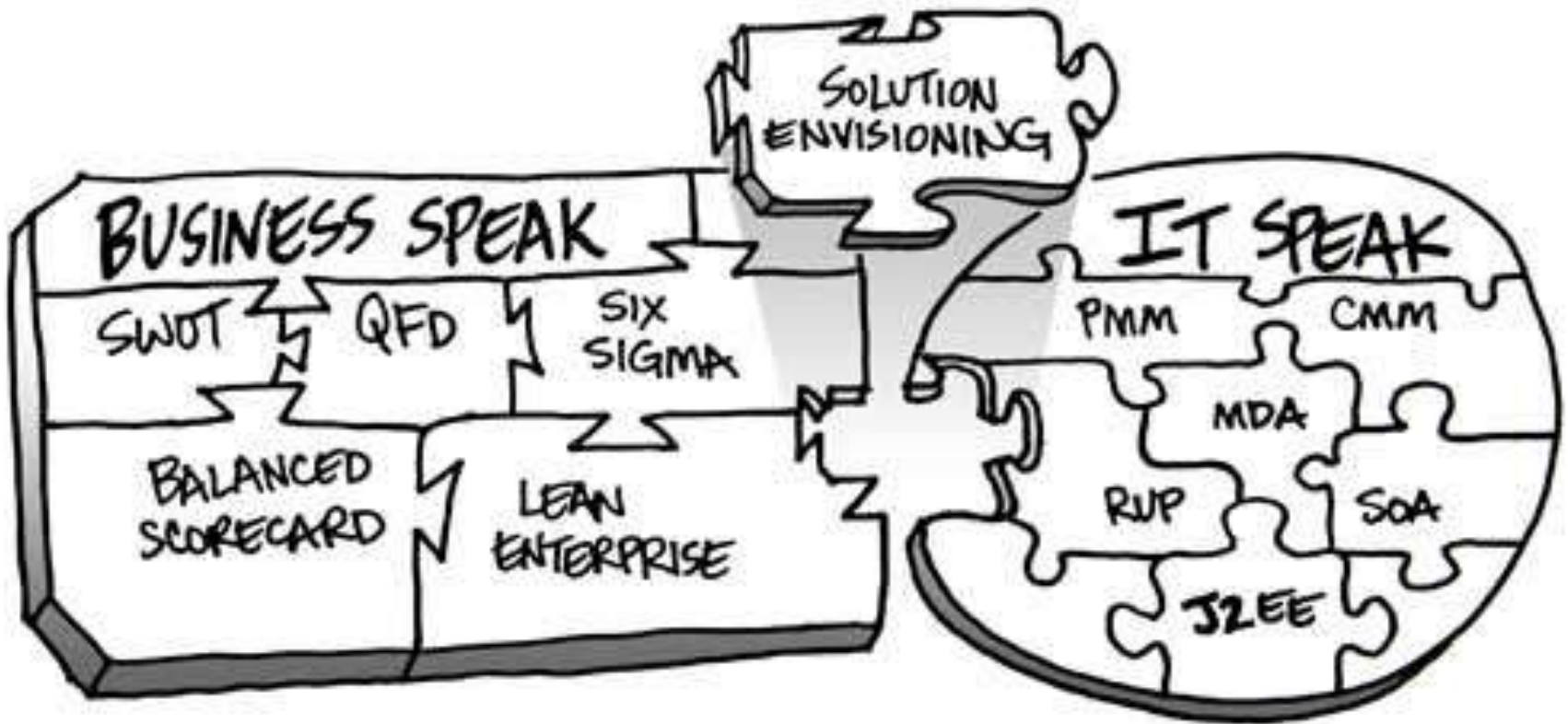
**Ralph Hodgson, CTO, TopQuadrant Inc.  
NASA NExIOM Ontology Lead**

# Agenda

- Introductions
- What is SOA
- Promise of SOA
- Data Interoperability  
Obstacle to SOA
- How Semantic Web  
Technologies Help
- NASA and MoJ Work
- Q&A



# Reminder to Myself



# What is Service-Oriented Architecture



# The Evolution of Service-Oriented Architecture

1995

1998

2001

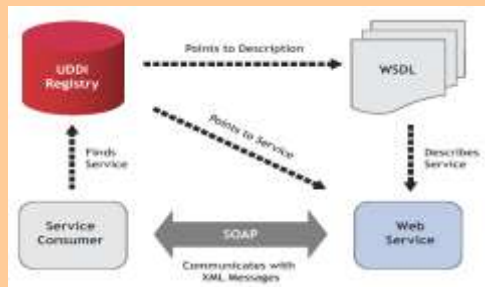
2004

2007

2010



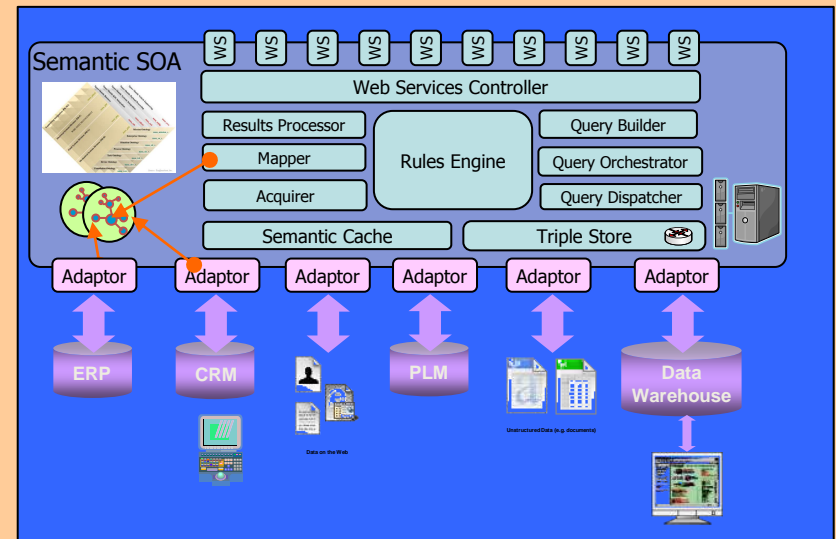
CORBA/COM JINI SOAP WSDL WS-\* REST The "CLOUD" Linked Open Data



**WSDL**

Service Composition	BPEL4WS	
Composable Service Assurances	<i>Security</i> WS-Security WS-Trust WS-SecureConversation WS-Federation	<i>Transactions</i> WS-Coordination WS-AtomicTransaction WS-BusinessActivity
Description	WS-ReliableMessaging	
Messaging	XSD, WSDL, UDDI, WS-Policy	
Transport	XML, SOAP, WS-Addressing, WS-Routing	
	HTTP, TLS, MSMQ, SMTP	

**WS-\***



**Ontology-Driven SOA**

# Some Key Moments in the Evolution of Open Semantic Web Technology in U.S. eGovernment

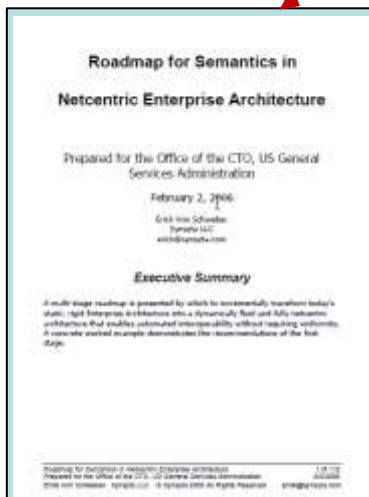
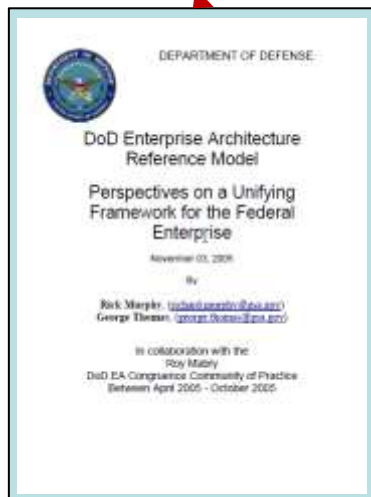
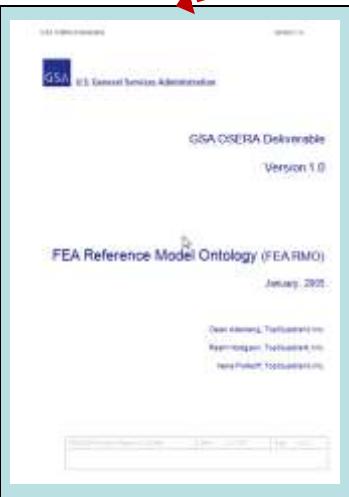
2003

2005

2007

2009

2011



<http://www.oegov.org>

<http://www.acq.osd.mil/jctd/articles/OTDRoadmapFinal.pdf>

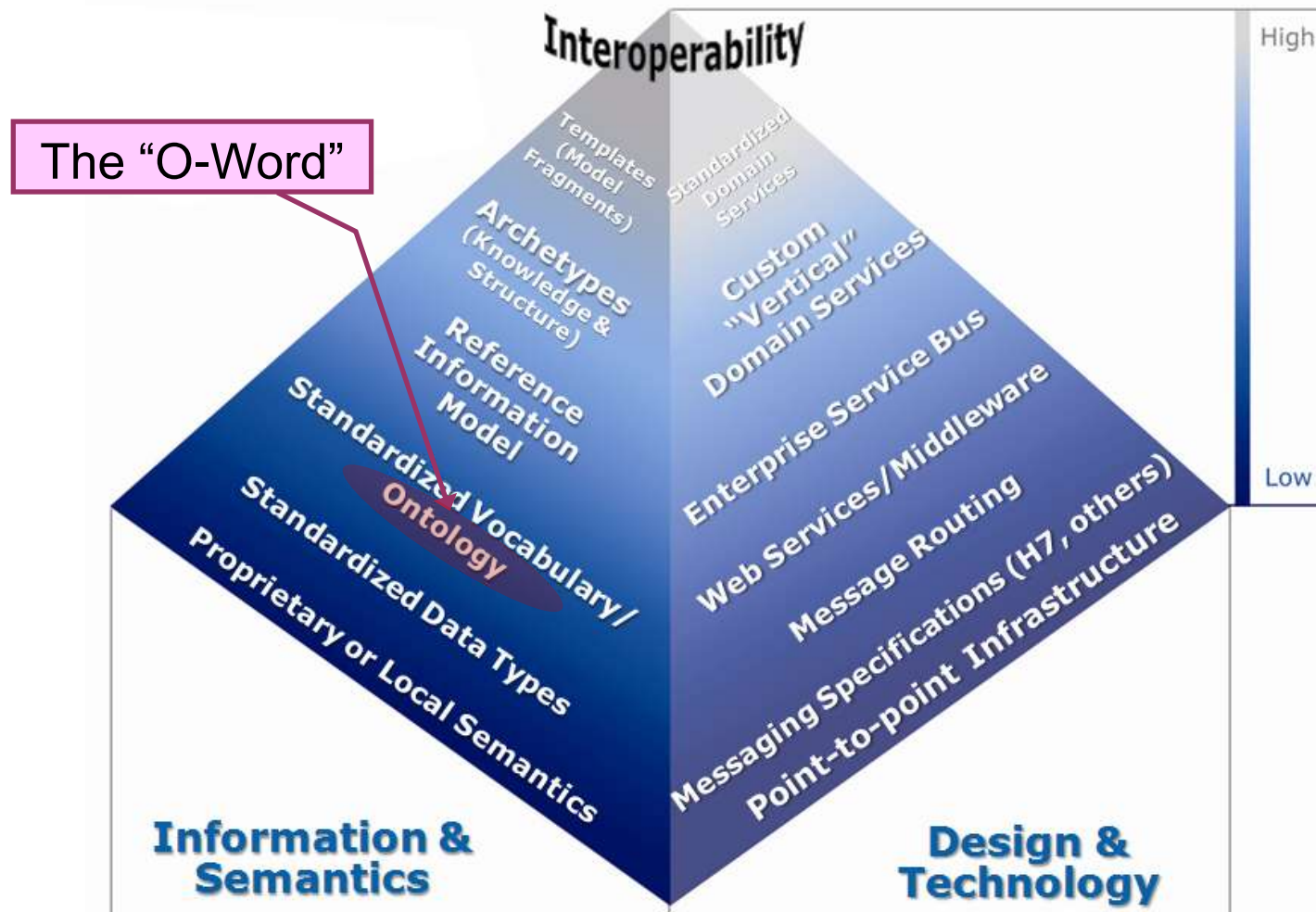
[http://www.w3.org/egov/wiki/Use\\_Case\\_8\\_-\\_Linked\\_Open\\_Government](http://www.w3.org/egov/wiki/Use_Case_8_-_Linked_Open_Government)

<http://colab.cim3.net/file/work/SOACoP/Roadmap%20for%20Semantics%20in%20Netcentric%20Enterprise%20Architecture.pdf>

[http://cio-nii.defense.gov/docs/20051102-GSA\\_DoD\\_Ontology\\_final.pdf](http://cio-nii.defense.gov/docs/20051102-GSA_DoD_Ontology_final.pdf)

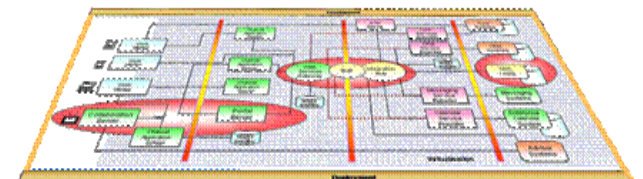
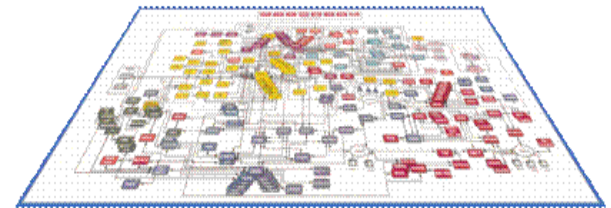
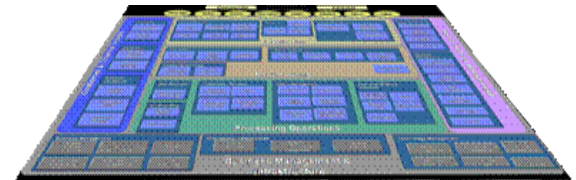


# The Healthcare SOA Pyramid



# The Promised Benefits of SOA

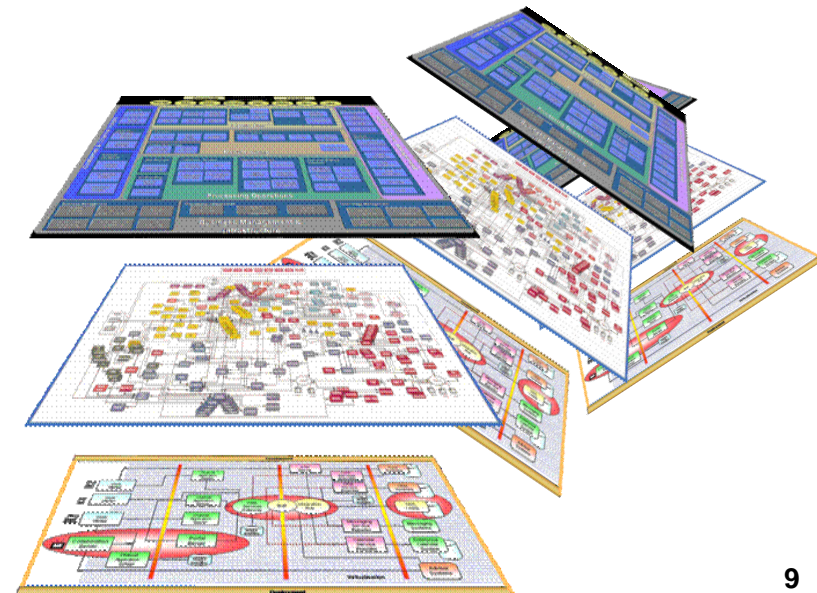
- Reuse of “Heritage Systems”
  - ❖ Build new functionality on top of existing Business Services
- Change Resilience
  - ❖ Insulation through robust interfaces
- Maintainability
  - ❖ Change can be incremental
- Composability
  - ❖ Services can be composed
- Agility
  - ❖ systems can evolve as the business changes





# But the promise depends on Semantics

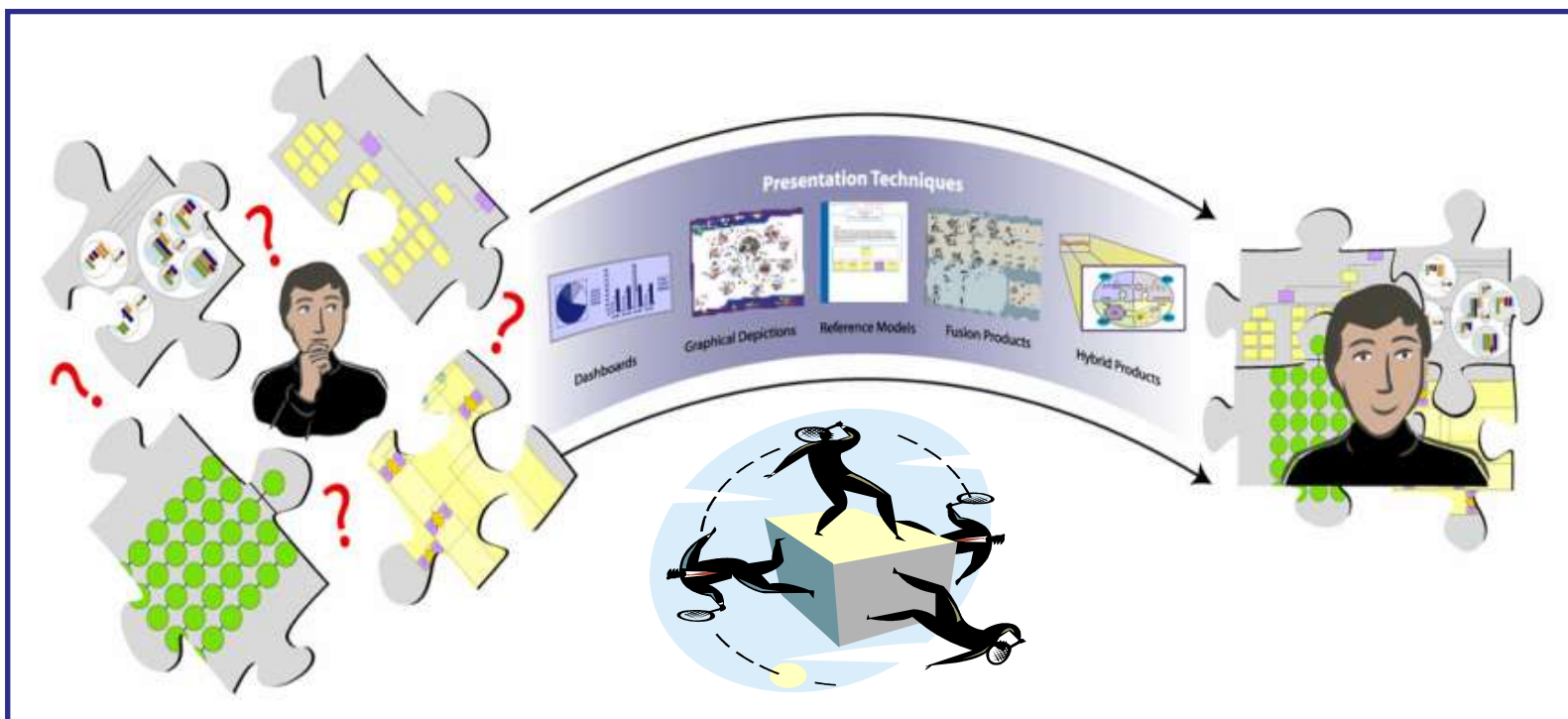
- If Services are not “Findable”, “Knowable” and “Composable” then:
  - ❖ SOA fails
- If data is not “knowable” across services then:
  - ❖ many mappings and transformations are needed
  - ❖ controlled vocabularies and code-lists diverge
  - ❖ And SOA fails





# A Key Obstacle for SOA

- Data is in many different systems that are not designed with data sharing in mind



# And

- One-off mappings increases complexity, brittleness and rigidity of the overall system, with data misalignments:

- ❖ **Correctness**

- ☐ Usual notion for data quality; is it right?
- ☐ Misspellings, out-of-date data, etc.

- ❖ **Understandability**

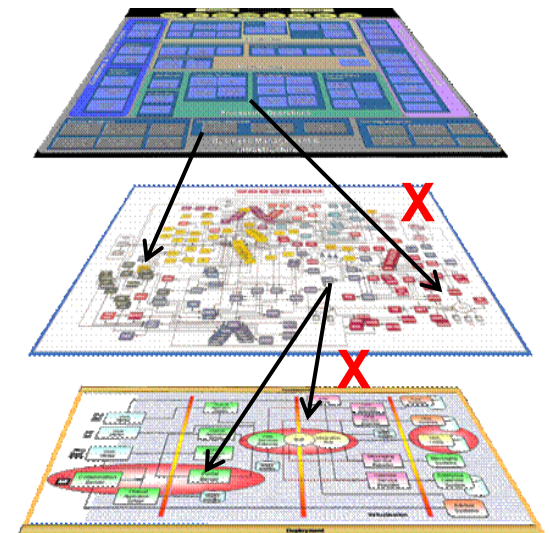
- ☐ Found data requires interpretation.
- ☐ E.g., what do the properties mean?

- ❖ **Accessibility**

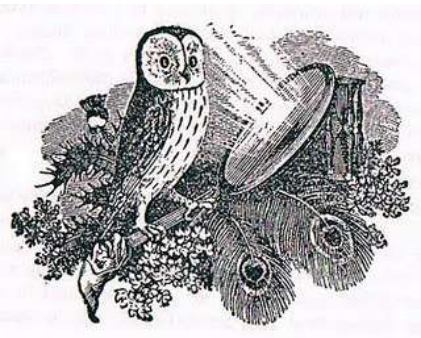
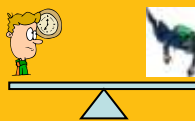
- ☐ How easily can the data be organized?.

- ❖ **Reusability/Repurposing**

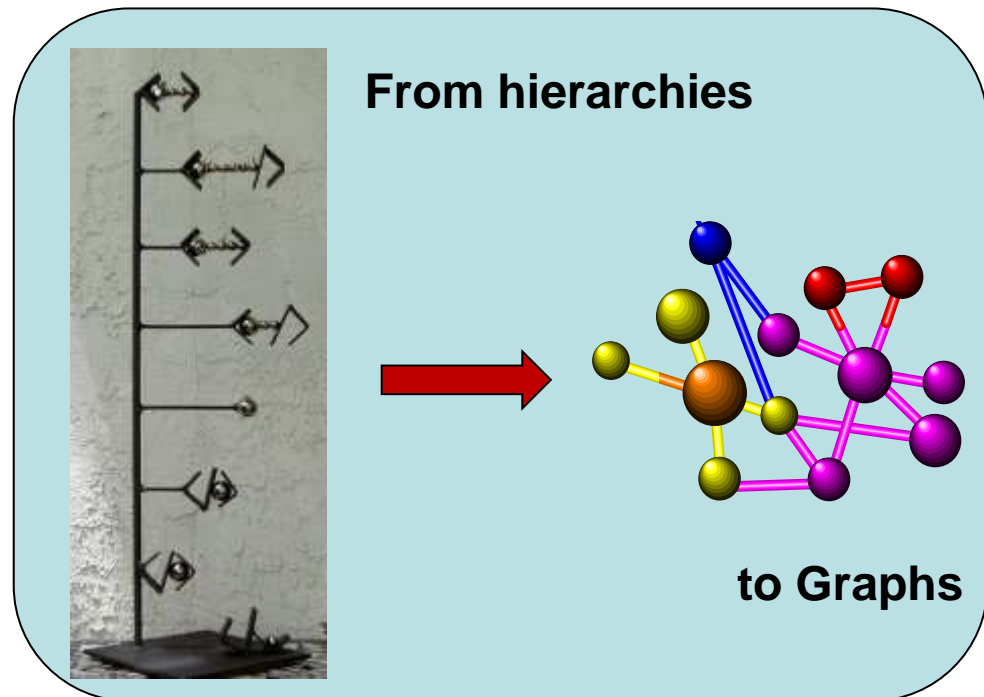
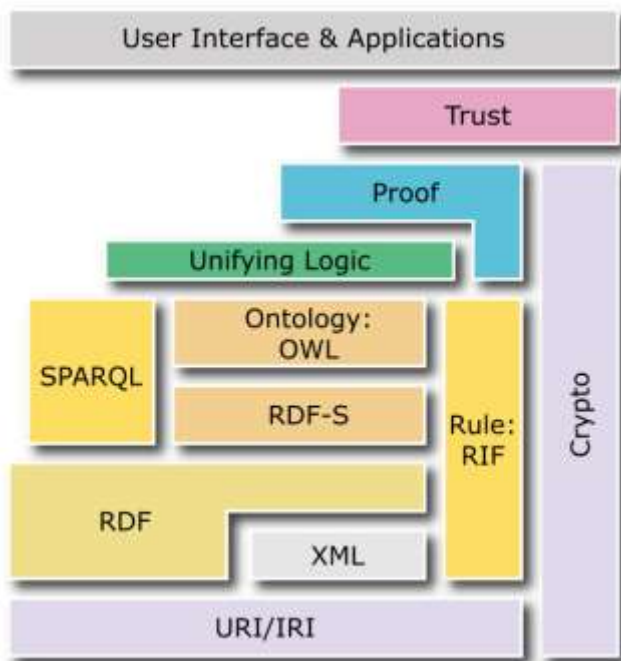
- ☐ No references to Controlled Vocabularies
- ☐ No use of standardized properties



# So what does OWL offer us? – think of it as XML++

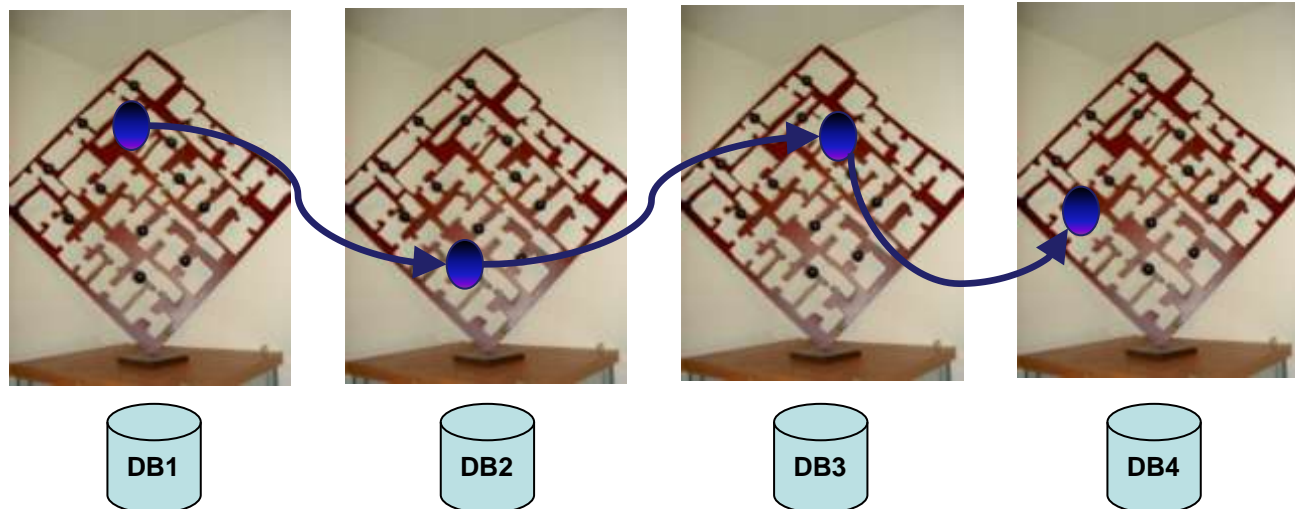


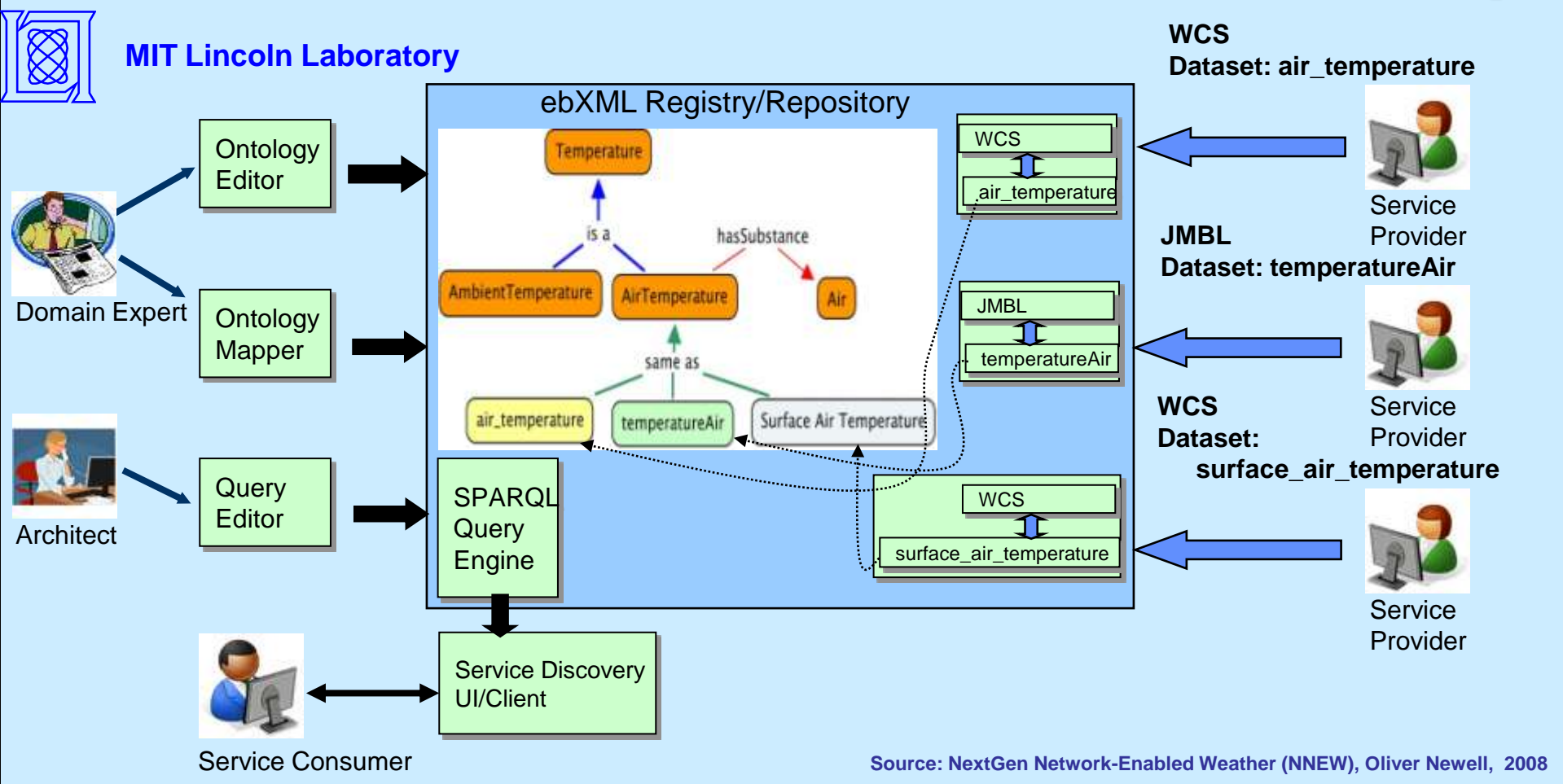
- OWL = Web Ontology Language
  - A language for describing subject areas of interest
  - Classes of things, things, properties of and relationships between things
  - A standard defined by the World-Wide Web Consortium (W3C)
- How does OWL relate to XML?
  - OWL is built on the Resource Description Framework (RDF)
  - OWL allows us to say things that XML Schema cannot say
  - OWL can be serialized in XML



# How Semantic Web Standards Help

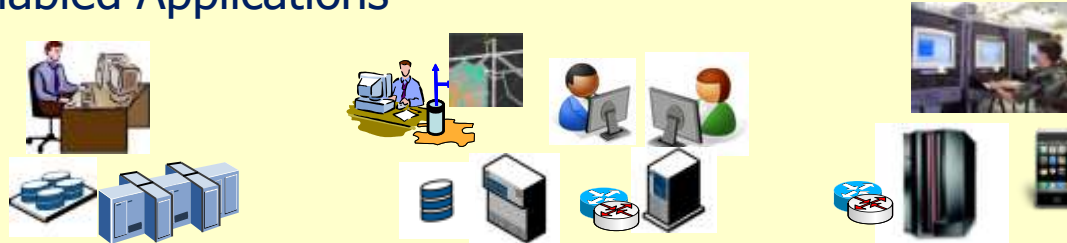
- They capture, align and resolve the data semantics of different data sources through:
  - ❖ Flexibility of the RDF data model and
  - ❖ Rich modeling formalisms of OWL and
  - ❖ A standards-based approach





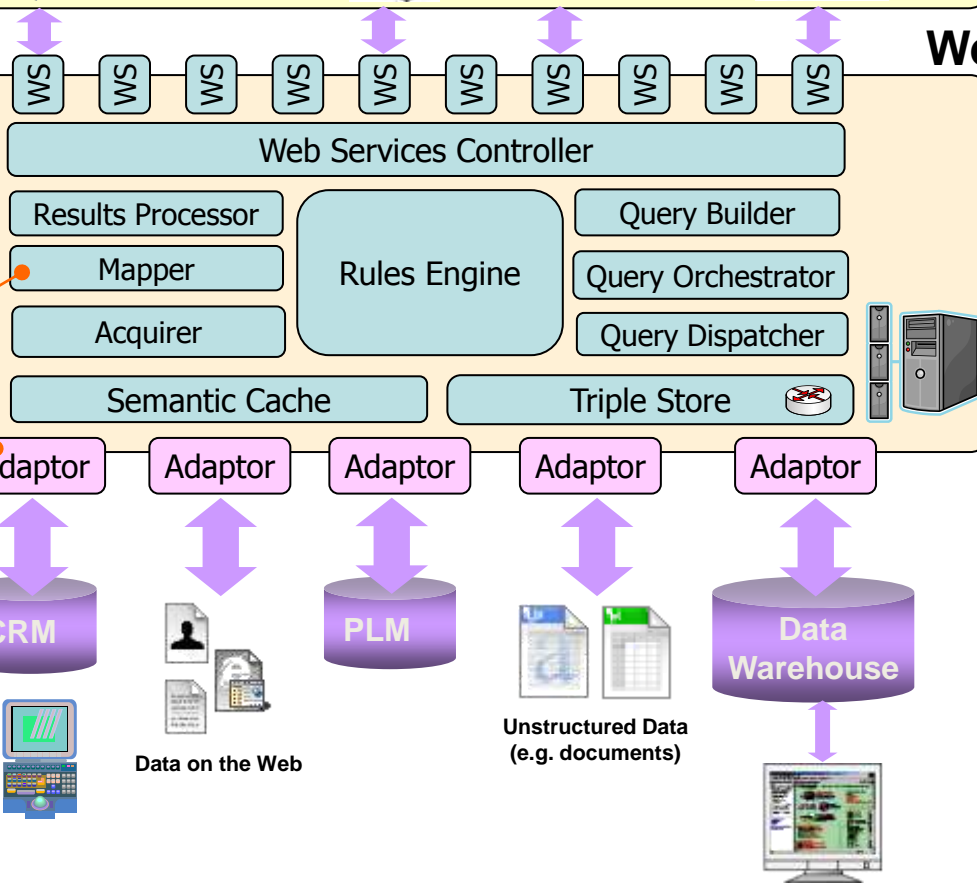
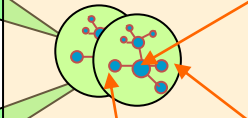
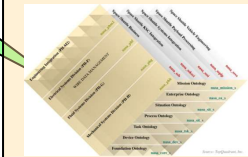
# Ontology-Driven SOA Conceptual Architecture

## SOA-Enabled Applications



People or programs interact through the semantic business layer within more powerful applications.

## Semantic SOA



## Web Services

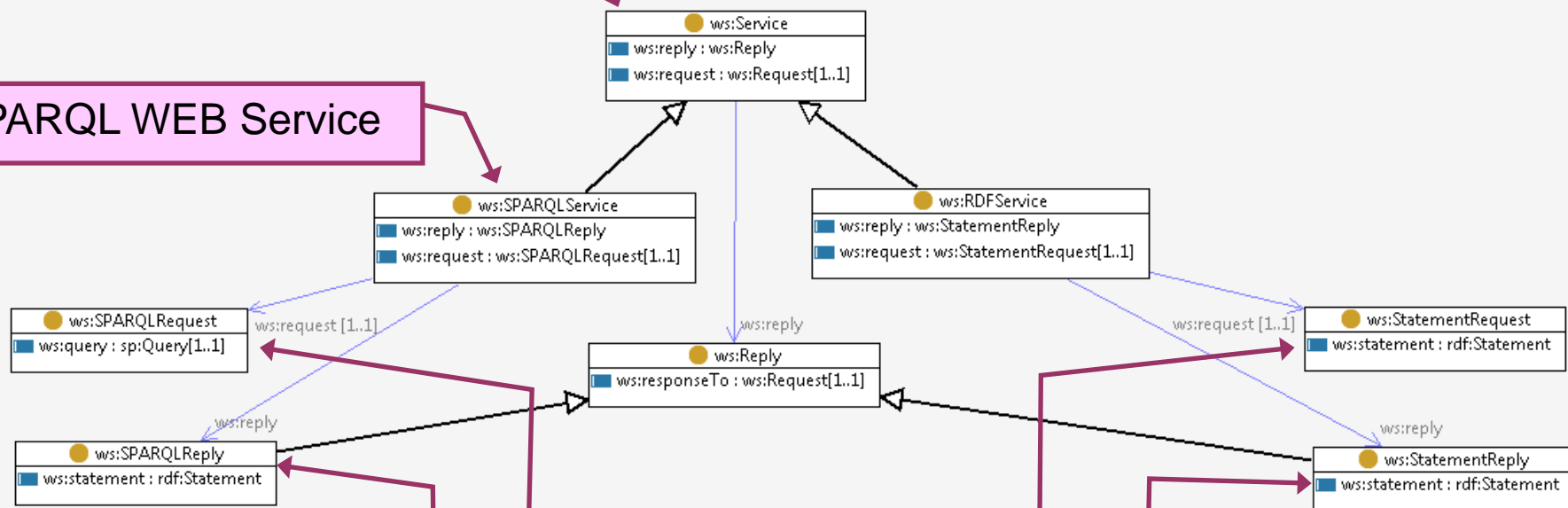
Semantic SOA layer defines standard vocabularies, formal models and semantic relationships between data sources.

Data are mapped to the semantic layer to provide integrative views, queries and other services.

# RDF/OWL Based Web Services

WEB Service Class

SPARQL WEB Service



SPARQL REPLY Triples

SPARQL REQUEST Triples

RDF REPLY Triples

RDF REQUEST Triples

# Implementing Web Services in SPARQL

- Web service calls to SPARQL-Based scripts
  - URL embedded in any HTML or application

<http://localhost:8083/tbl/actions?action=sparqlmotion&id=FindByCallingCode&callingCode=61>

Live server URL

Function name

parameters

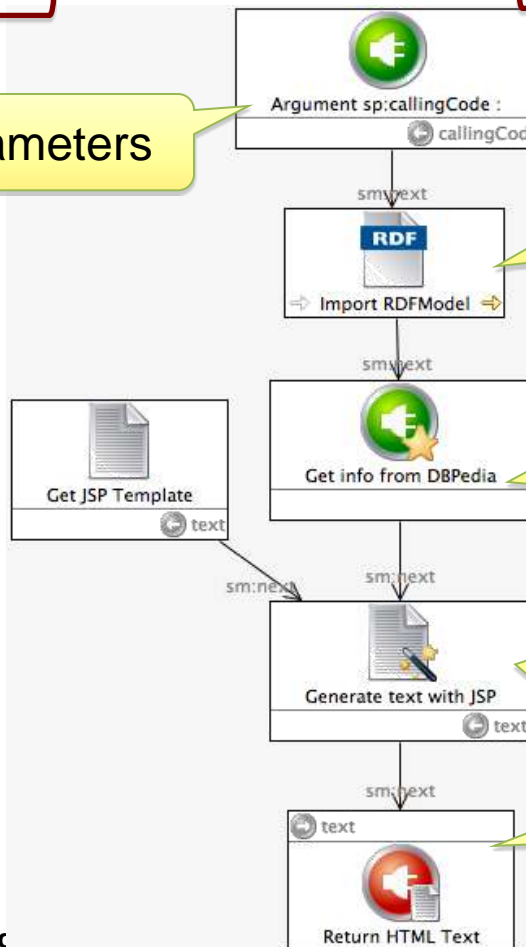
Get parameters

Import Data

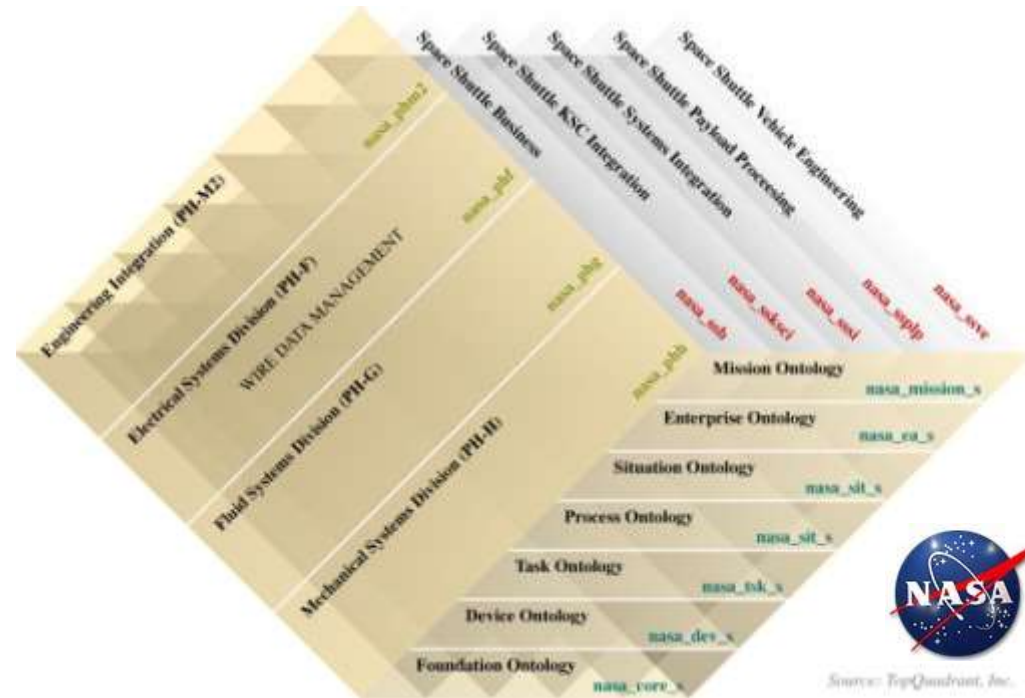
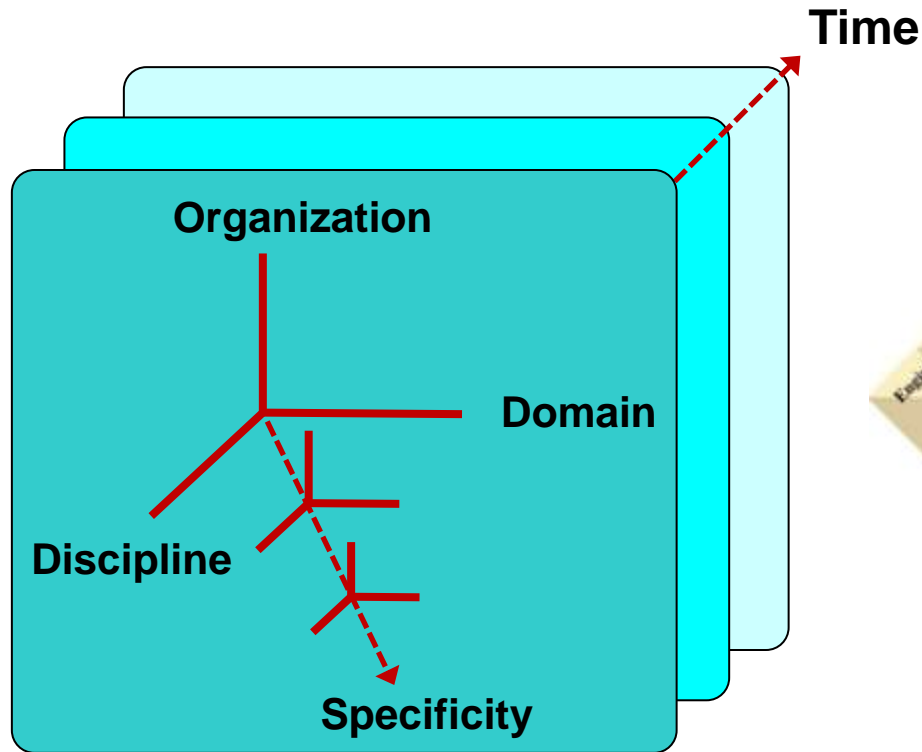
Get linked data from DBPedia

Create text from JSP template

return text

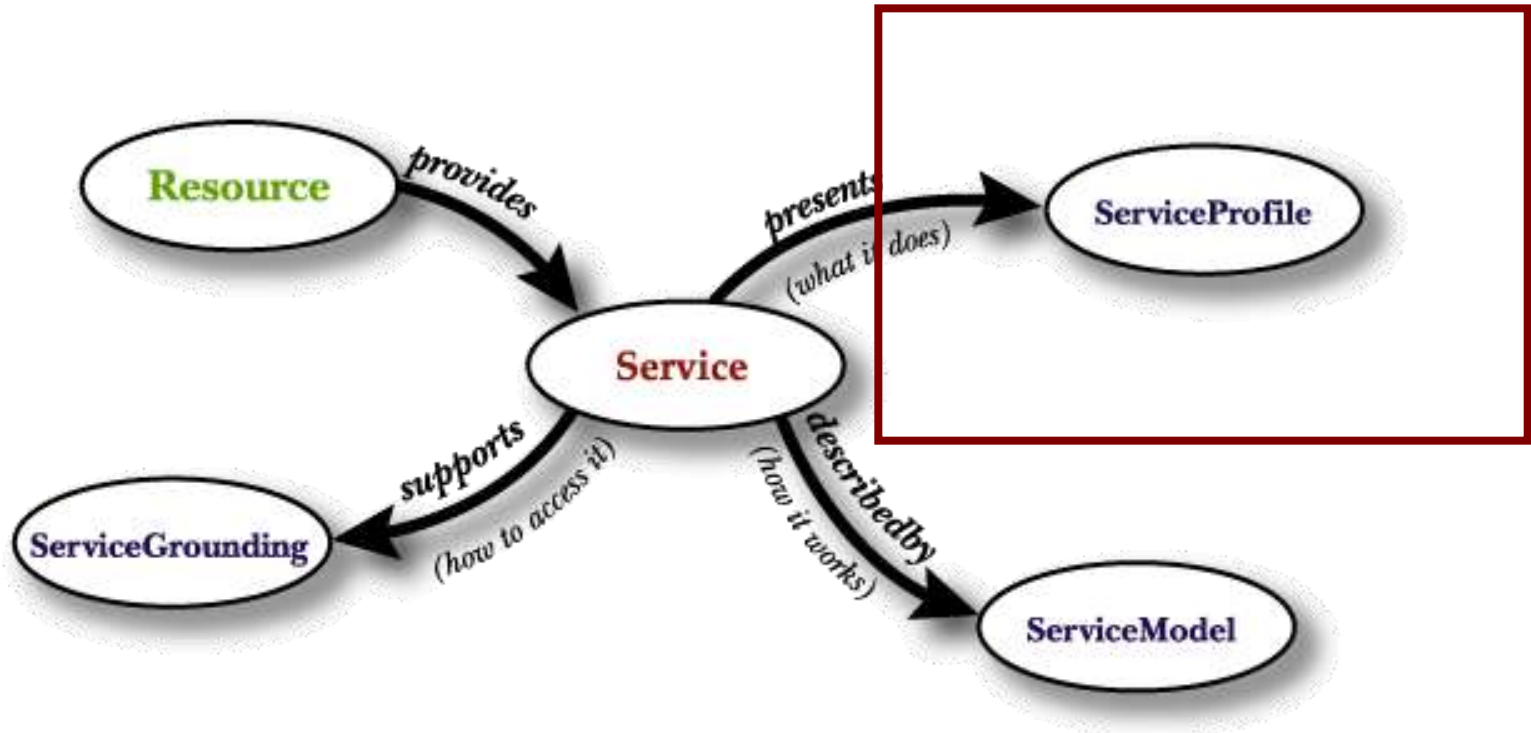


# Key to Success is an Ontology Architecture - Five Dimensions turn out to be important



Ontologies are partitioned according to domains, disciplines, organizations, levels of specificity and time. Named graphs are aggregated through configuration ontologies according to specific needs.

# OWL-S did a reasonable job of an Ontology of Services



*Ontology images compliments of Terry Payne,  
University of Southampton*

The diagram illustrates the structure of a 'Functionality Description' using UML classes and relationships. The classes and their attributes are as follows:

- Actor** (Class):
  - Attributes: `phone` (xsd:string), `email` (xsd:string), `fax` (xsd:string), `title` (xsd:string).
- QualityRating** (Class):
  - Attributes: `ratingName` (xsd:string), `rating` (Thing).
- ServiceParameter** (Class):
  - Attributes: `serviceParameterName` (xsd:string), `sParameter` (Thing).
- ServiceCategory** (Class):
  - Attributes: `categoryName` (xsd:string), `taxonomy` (xsd:string), `code` (xsd:string).
- ParameterDescription** (Class):
  - Attributes: `parameterName` (xsd:string), `restrictedTo` (daml+oil:Class), `refersTo` (process:parameter).

Relationships between the classes are defined by directed associations:

- Actor** to **QualityRating**: Association labeled `contacting`.
- Actor** to **ServiceParameter**: Association labeled `serviceCategory`.
- Actor** to **ServiceCategory**: Association labeled `parameter`.
- Actor** to **ParameterDescription**: Association labeled `subPropertyOf(parameter)`.
- ServiceCategory** to **ParameterDescription**: Association labeled `input`.
- ServiceParameter** to **ParameterDescription**: Association labeled `output`.
- QualityRating** to **ParameterDescription**: Association labeled `precondition`.
- ServiceCategory** to **ParameterDescription**: Association labeled `effect`.

A red line highlights the path from the **Actor** class to the **ParameterDescription** class, emphasizing the `parameter` relationship.

**SOA**  
Symposium

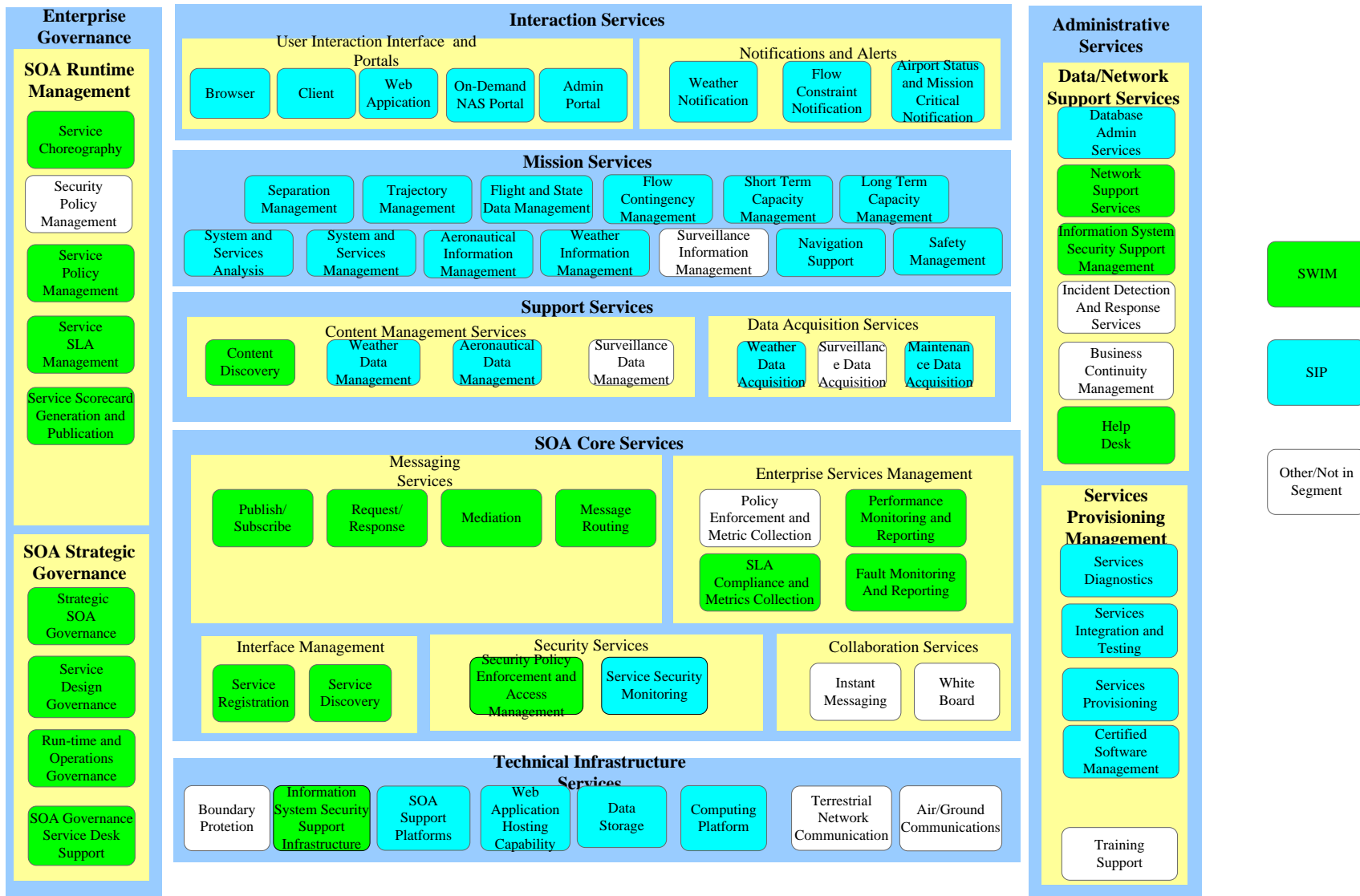
Government  
&  
Industry  
Best Practices

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# 1 How can SKOS, the Simple Knowledge Organization System be used for Service Directories



# Example of an SOA: NASEAF SV4 NAS Enterprise Services (SWIM Segment 2)



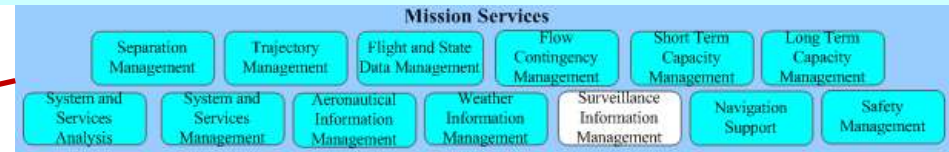
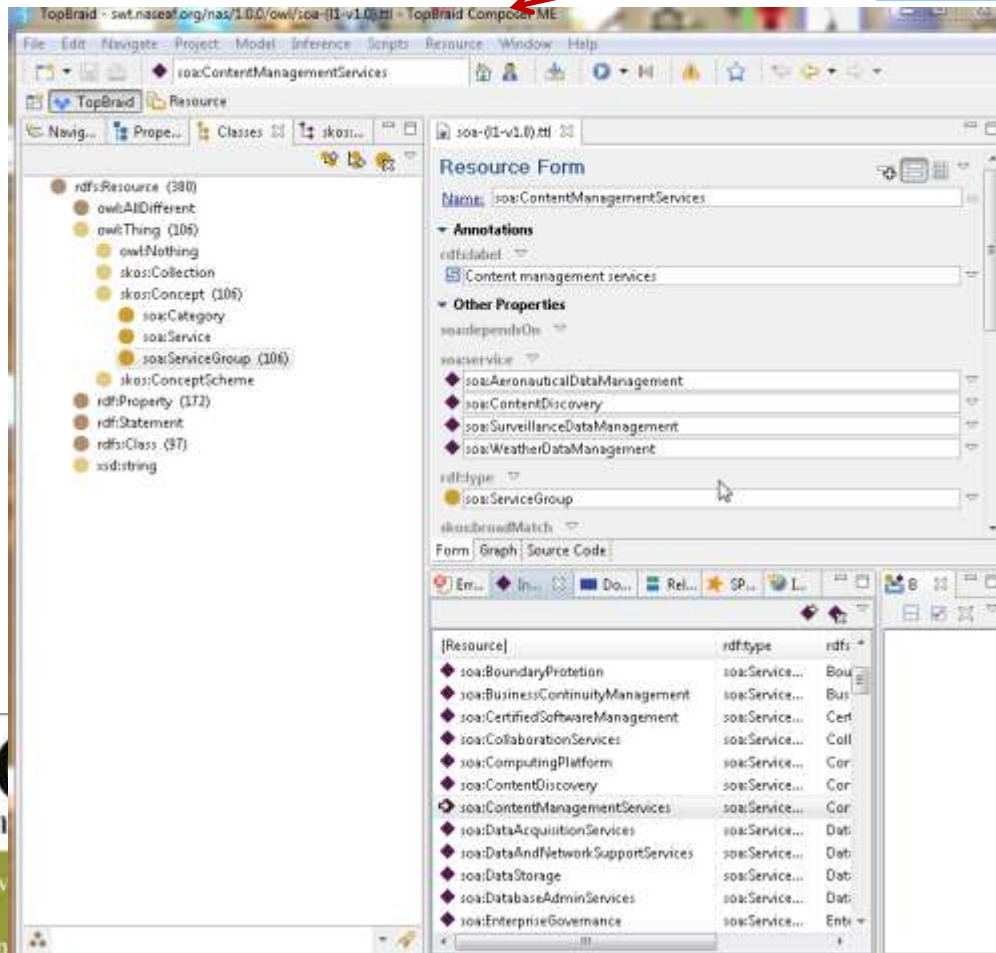
Source: "System Wide Information Management", Eurocontrol AP4 Team, Ahmad Usmani, SWIM Program Manager December 2009

Ref: SWIM – <http://www.swim.gov>

# Using SKOS to represent NASEAF SV4 NAS Enterprise Services

## SKOS - Simple Knowledge Organization System

### Ontology Editor



### Triples

#### soa:MissionServices

```

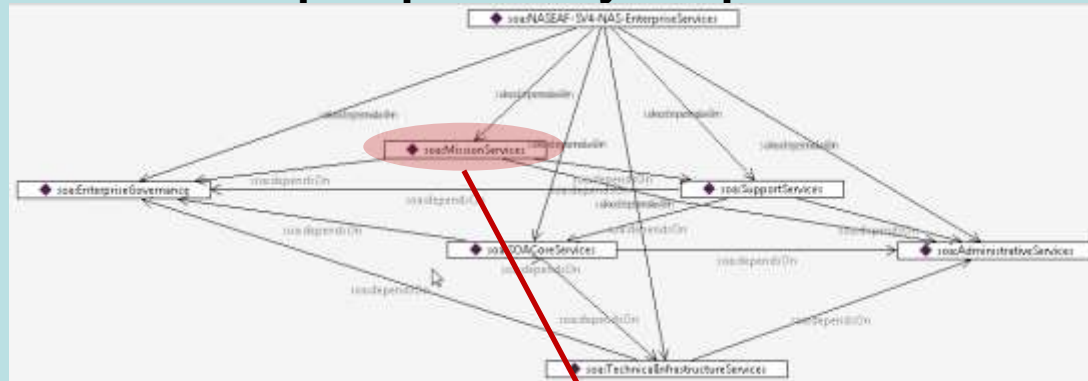
a      soa:ServiceGroup ;
rdfs:label "Mission services"^^xsd:string ;
soa:dependsOn
    soa:EnterpriseGovernance ,
    soa:AdministrativeServices ,
    soa:SupportServices;
skos:narrower
    soa:FlightandStateDataManagement ,
    soa:WeatherInformationManagement ,
    soa:SystemAndServicesManagement ,
    soa:SeparationManagement ,
    soa:LongTermCapacityManagement ,
    soa:FlowContingencyManagement ,
    soa:SafetyManagement ,
    soa:ShortTermCapacityManagement ,
    soa:AeronauticalInformationManagement ,
    soa:NavigationSupport ,
    soa:SystemAndServicesAnalysis ,
    soa:SurveillanceInformationManagement ,
    soa:TrajectoryManagement .
    
```

# NASEAF SV4 NAS Enterprise Services Ontology Views

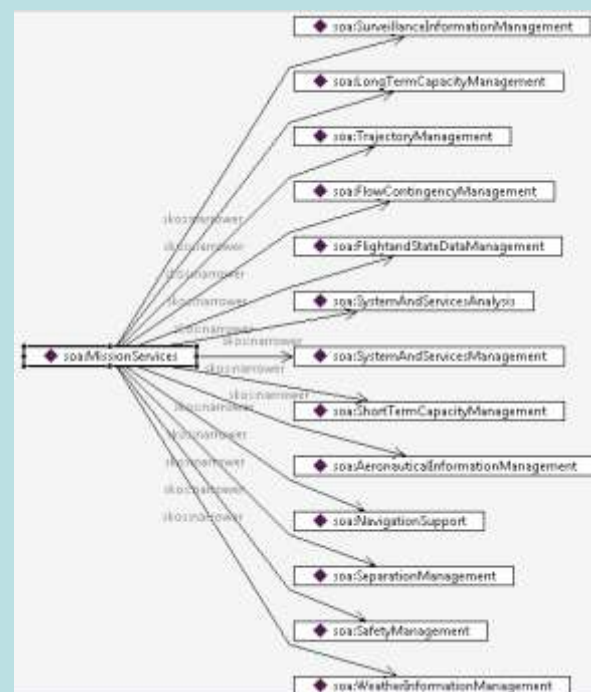
## Service Taxonomy

- ◆ soa:NASEAF-SV4-NAS-EnterpriseServices
  - ◆ soa:AdministrativeServices
    - ◆ soa:DataAndNetworkSupportServices
    - ◆ soa:ServicesProvisioningManagement
  - ◆ soa:EnterpriseGovernance
    - ◆ soa:SOARuntimeManagement
    - ◆ soa:SOAStrategicGovernance
  - ◆ soa:MissionServices
    - ◆ soa:AeronauticalInformationManagement
    - ◆ soa:FlightandStateDataManagement
    - ◆ soa:FlowContingencyManagement
    - ◆ soa:LongTermCapacityManagement
    - ◆ soa:NavigationSupport
    - ◆ soa:SafetyManagement
    - ◆ soa:SeparationManagement
    - ◆ soa:ShortTermCapacityManagement
    - ◆ soa:SurveillanceInformationManagement
    - ◆ soa:SystemAndServicesAnalysis
    - ◆ soa:SystemAndServicesManagement
    - ◆ soa:TrajectoryManagement
    - ◆ soa:WeatherInformationManagement
  - ◆ soa:SOACoreServices
    - ◆ soa:CollaborationServices
    - ◆ soa:EnterpriseServicesManagement
    - ◆ soa:InterfaceManagement
    - ◆ soa:MessagingServices
    - ◆ soa:SecurityServices
  - ◆ soa:SupportServices
    - ◆ soa:ContentManagementServices
    - ◆ soa:DataAcquisitionServices
  - ◆ soa:TechnicalInfrastructureServices
    - ◆ soa:AirAndGroundCommunications
    - ◆ soa:BoundaryProtetion
    - ◆ soa:ComputingPlatform

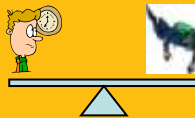
## Service Group Dependency Graph



## Mission Services Taxonomy

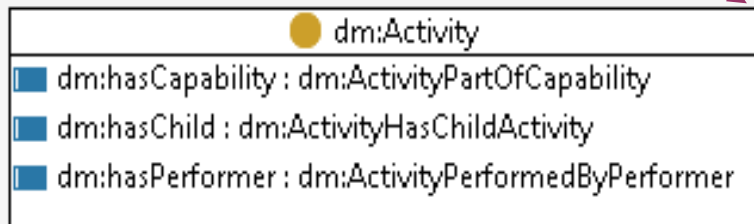


# SOA and DoD BEA – a DM2 Ontology Example



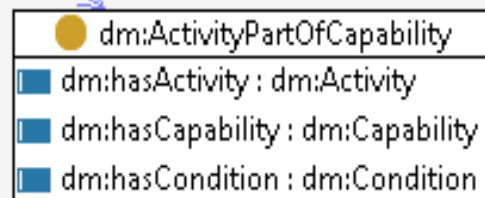
The BEA provides an EA framework for controlling and provisioning Web Services in an SOA

Activity can be used to navigate to Capabilities

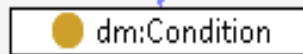


dm:hasActivity

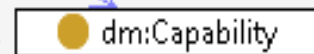
dm:hasCapability



dm:hasCondition



dm:hasCapability



Capabilities may be constrained by Conditions

Capabilities connect to Web Services in an SOA

# 2 How can OWL and RDF help Data Interoperability

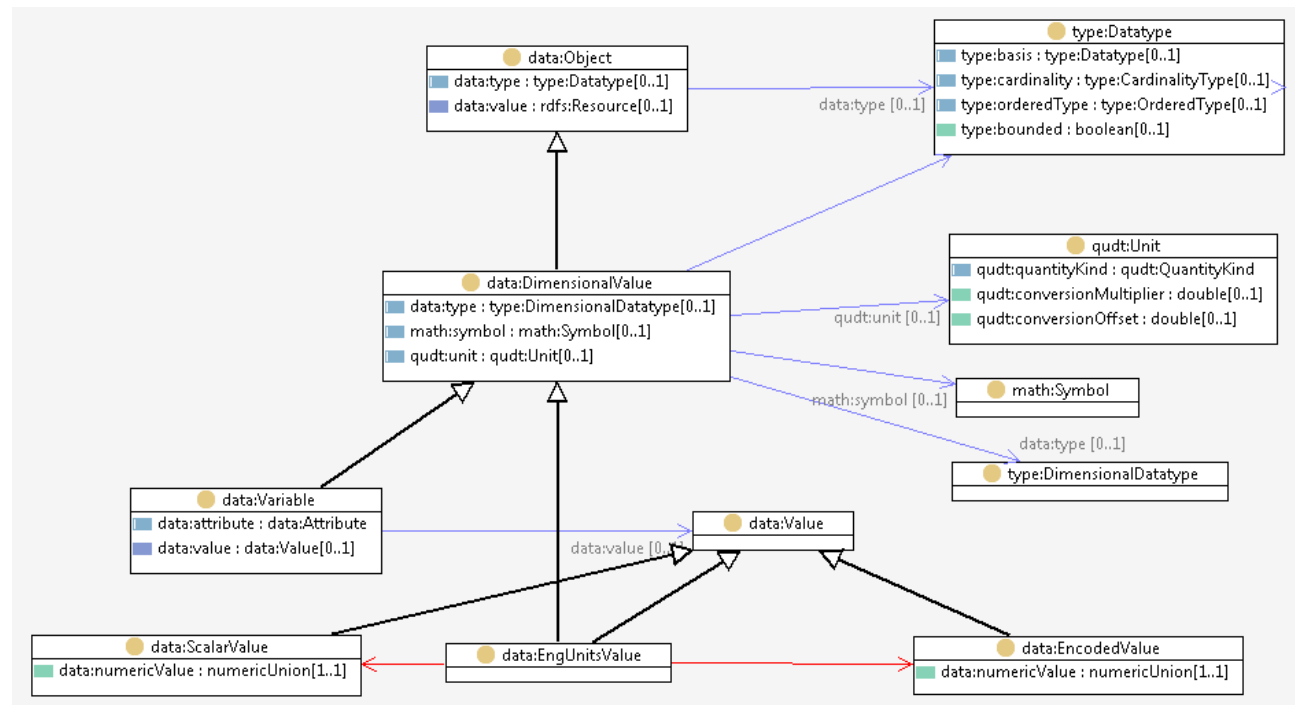


# Basic Data Interoperability Needs

## ■ Data values have known:

- ❖ data types
- ❖ bit and byte order
- ❖ Units
- ❖ Quantities

### Part of the QUDT Data Ontology



# The NASA QUDT Ontologies



- Quantity, Units, Dimensions and Datatypes
  - ❖ From the NASA 300+ Ontology Collection
  - ❖ Schema – 200 Classes, 61 Properties
  - ❖ Quantities – 239 (e.g. Time, Volume, Mass)
  - ❖ Units – 239 (e.g. Foot, Meter, Furlong)
  - ❖ Dimensions – 460 (e.g. CGS, SI, Planck, Gauss)
  - ❖ Data and types – Forthcoming
  - ❖ NIST – 648 Constants (e.g. Planck, Electron Volt)
  - ❖ Undergoing OASIS Standardization


**ref: <http://www.qudt.org>**

# Constraining Units

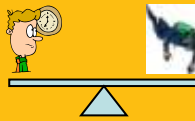
## *spin:constraint – Constrain the Measurement Unit System*

```
spin:constraint ▾
★ ASK WHERE {
  ?this qudt:unit ?unit .
  ?system qudt:systemDefinedUnit ?unit .
  FILTER (?system != unit:SystemOfUnits_SI) .
}
```

### Interpretation:

- For a given measurement (**?this**), require that its **?unit** is a member of the Metric System (unit:SystemOfUnits\_SI)
- Signal a constraint violation if this is **not** the case 

# Rules for Data Conversion



## *spin:construct – Infer a Converted Measurement*

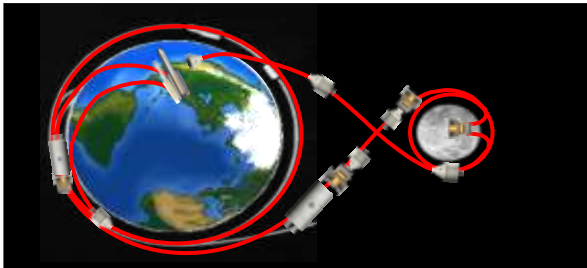
```
spin:constructor
★ CONSTRUCT {
  ?this qudt:numericValue ?imperialValue .
  ?this qudt:unit ?imperialUnit .
  ?this acme:displayValue ?displayValue .
}
WHERE {
  ?metricQV qudt:numericValue ?metricValue .
  ?metricQV qudt:unit ?metricUnit .
  ?metricUnit qudt:quantityKind ?kind .
  ?imperialUnit a acme:ImperialBaseUnit .
  ?imperialUnit qudt:quantityKind ?kind .
  LET (?imperialValue := qudtspin:convert(?metricValue, ?metricUnit, ?imperialUnit)) .
  LET (?displayValue := acme:roundNumber(?imperialValue, 3)) .
}
```

### Interpretation:

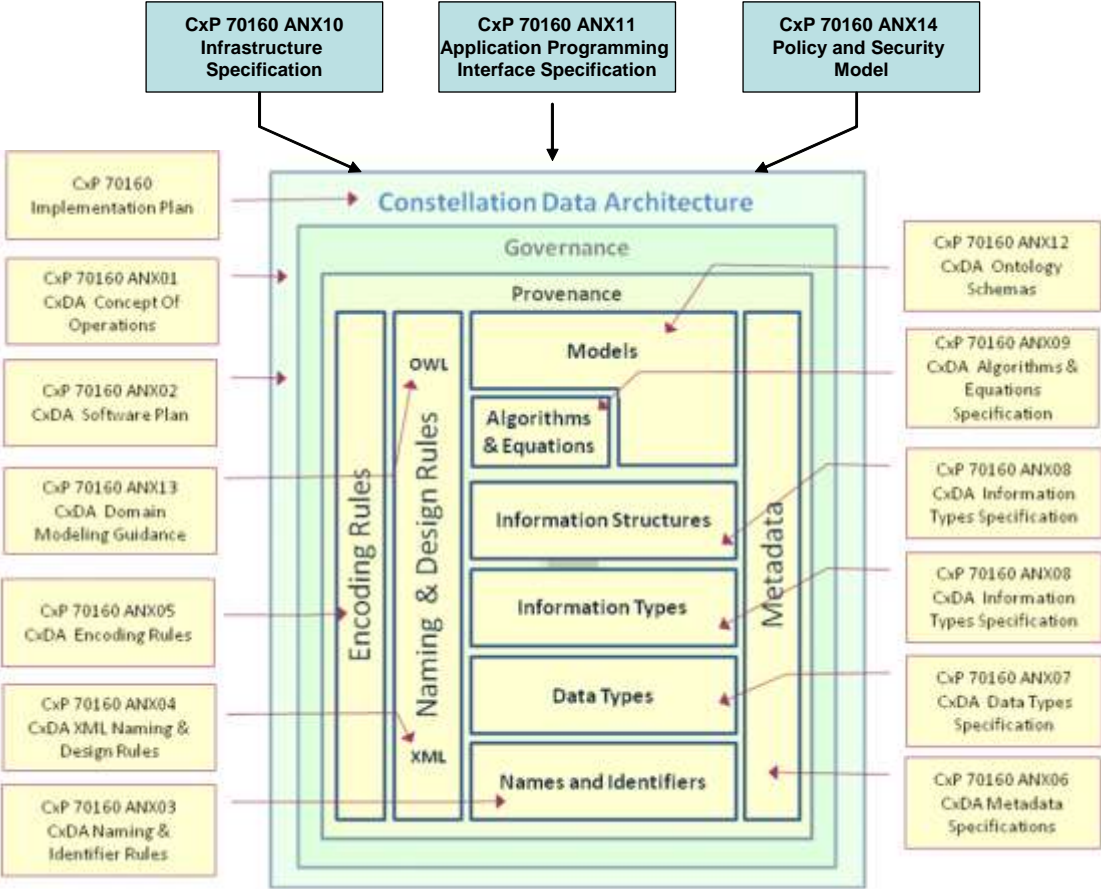
- For a given Metric measurement (**?metricQV**), take its **?metricValue**
- Convert the value into Imperial Units and round it
- Create (**CONSTRUCT**) a new measurement *instance* with the Imperial values

# 3 How can OWL and RDF help SOA and Web Service Specifications



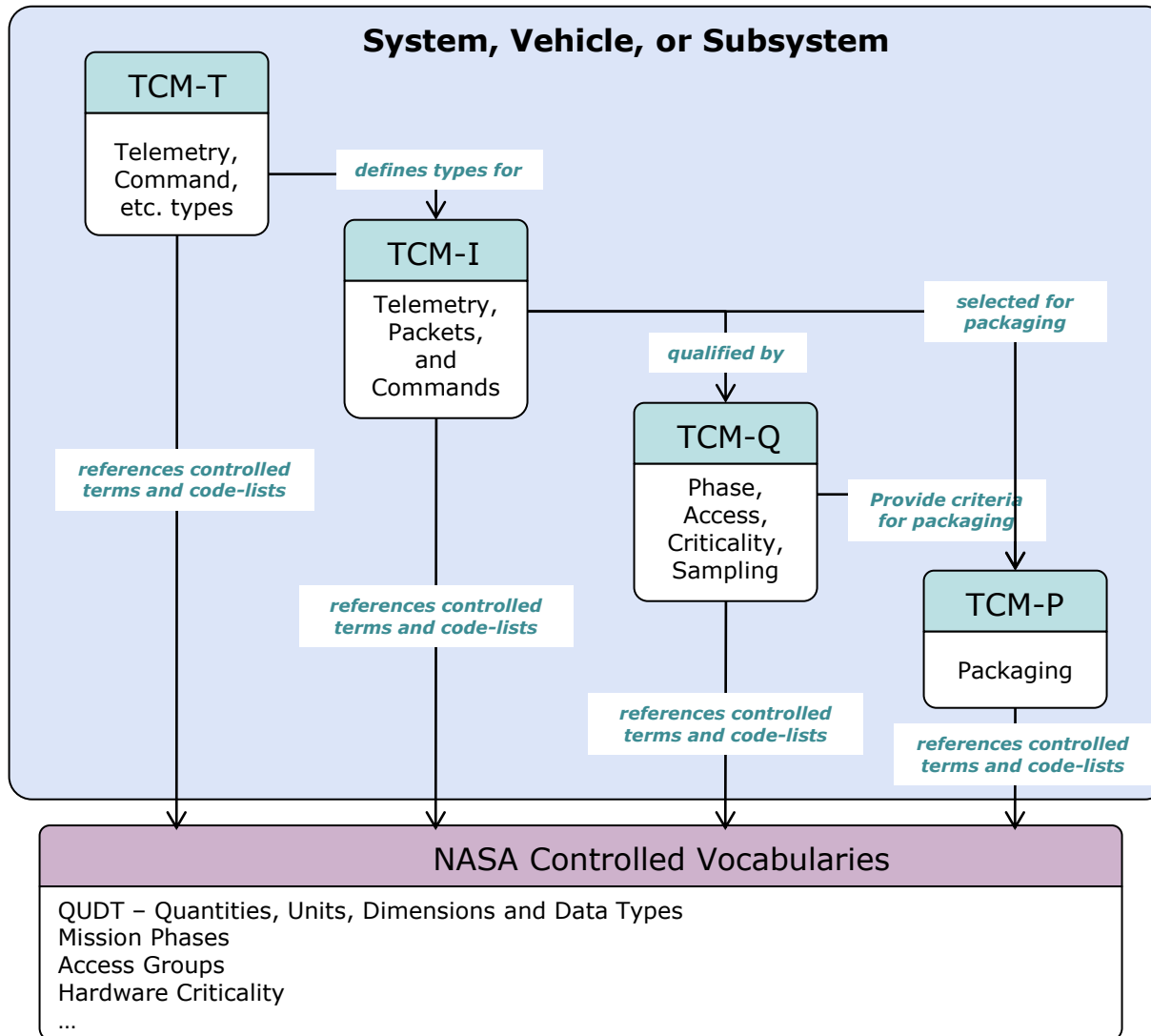


Constellation Program Data Architecture and Interoperability through the use of OWL Ontologies with strategies for co-existence with XML and other data formats.



Types ➤ Instances ➤ Qualification ➤ Packaging

Workflow

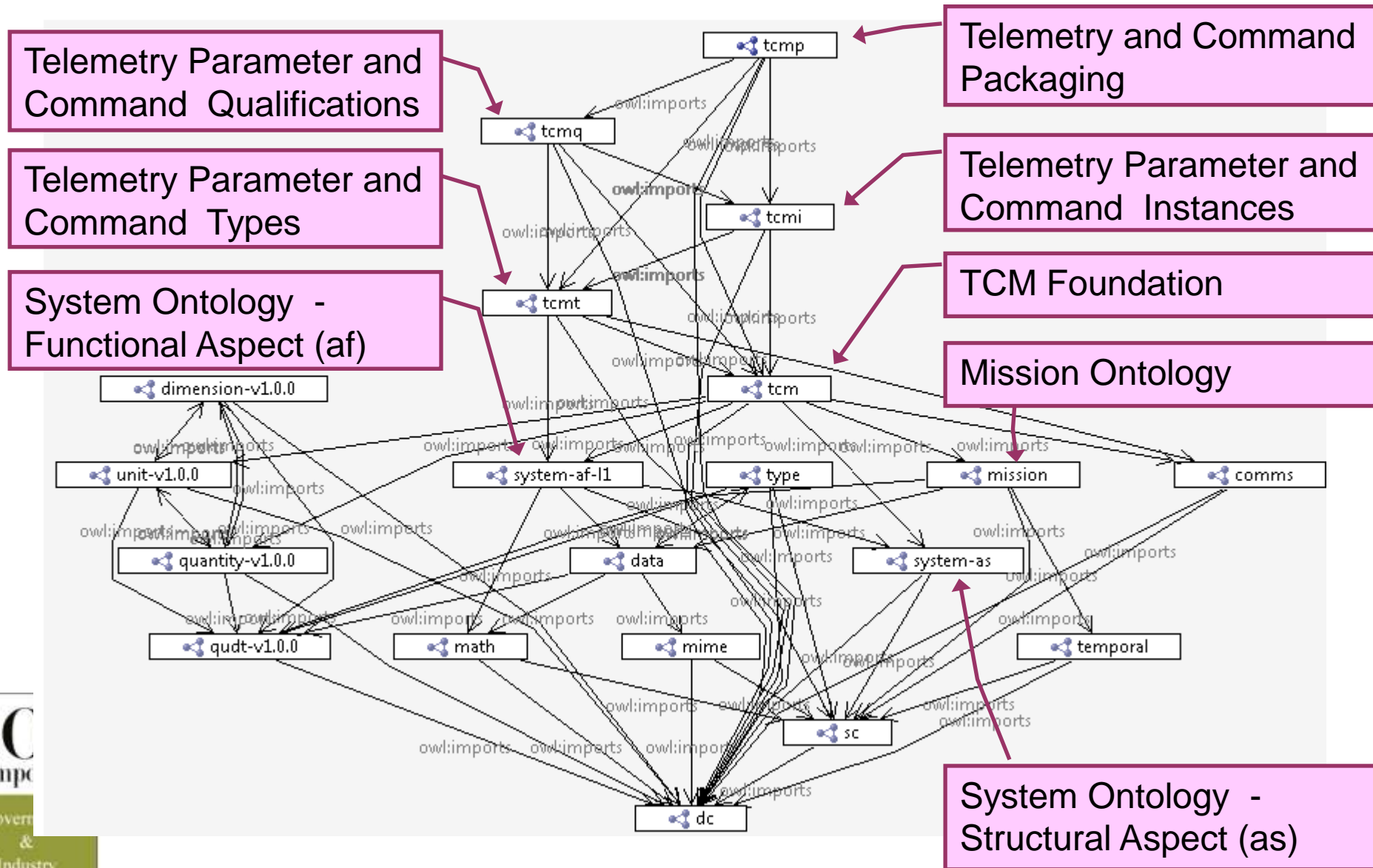


Ontology and Schema Components

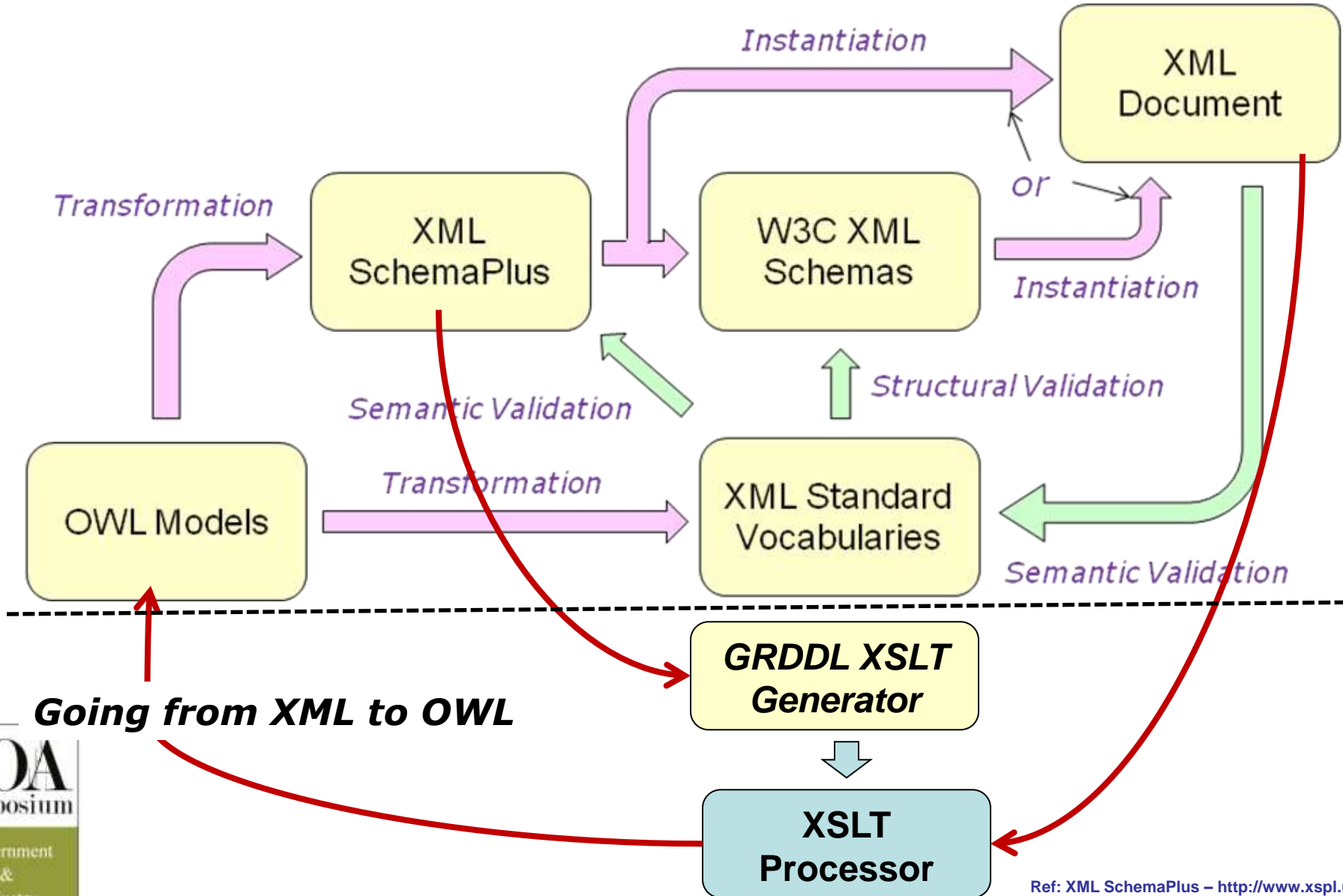


# TCMX Ontology Architecture builds of System SBFI and QUDT Ontologies





# Generating XML Schemas and Controlled Vocabularies



**Going from XML to OWL**

Ref: XML SchemaPlus – <http://www.xspl.us>

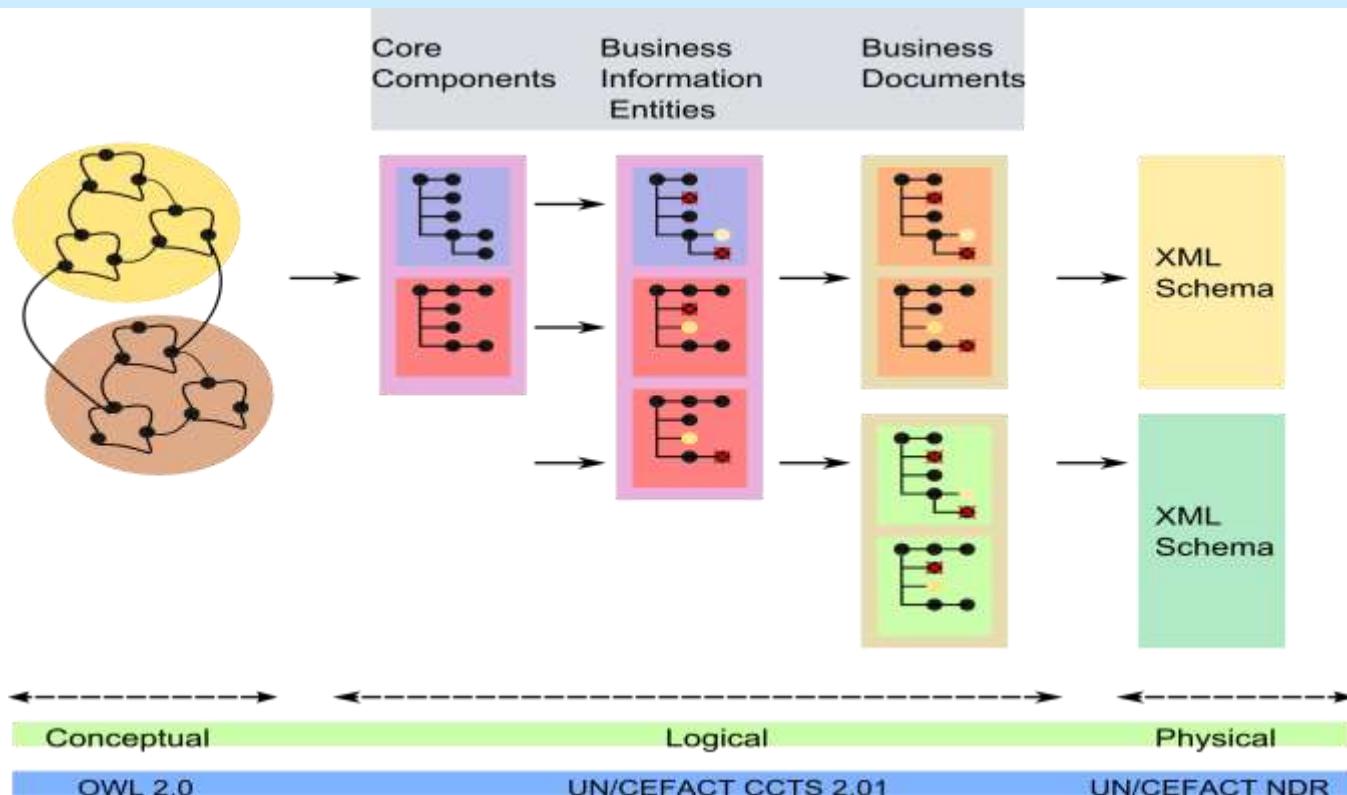
# Netherlands MoJ Approach to Message Design for Interoperability

## Problem: Seamless information sharing is challenging:

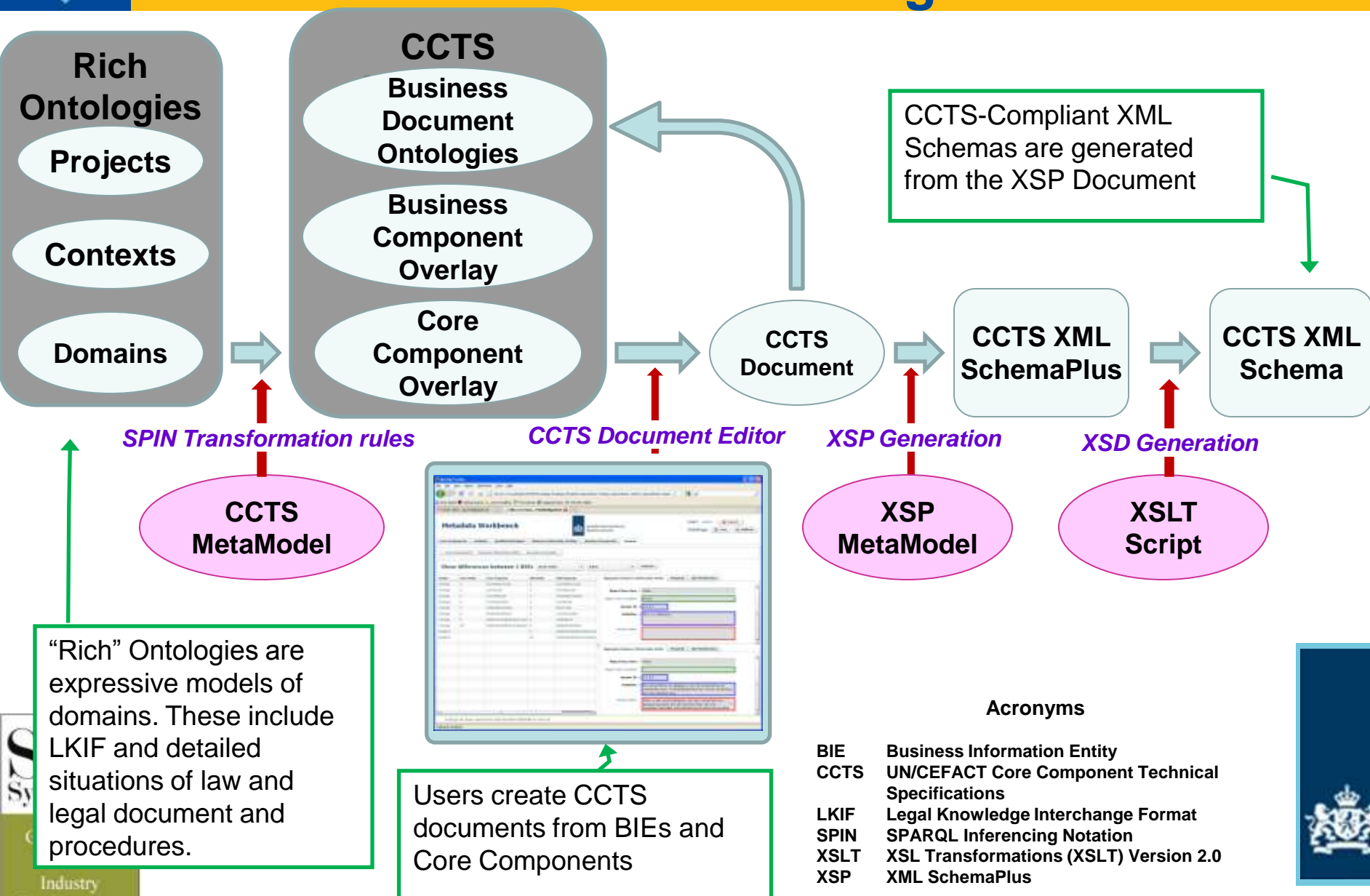
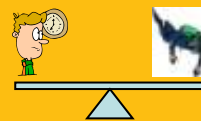
Data resides in many diverse systems supporting unique operation requirements of courts, police, hospitals, border control, motor vehicle, local and federal offices.

## Solution: Ontology-Based Metadata Workbench:

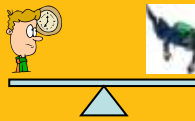
Transform “Rich” Ontologies into CCTS Ontologies and allow Business Analysts to assemble business documents for electronic messages from Component Parts.



# Netherlands MoJ – Creation of XML Message Schemas



# Closing Remarks



1. Ontologies should be used for specification to enable vendor-independent SOA and Web Services
  1. OWL can be used as a vendor-neutral specification language
  2. OWL is more expressive than XML, UML and ER models
2. OWL + Rules provides expressive support for data acquisition, interpretation, transformation and verification
  1. Data Exchange Engines should have ontologies of industry standards
3. OWL can interoperate with XML technologies through the use of (NASA) XML SchemaPlus and controlled vocabularies
  1. Controlled Vocabularies are key to SOA
4. SOA makes little sense if you don't have Data Quality
  1. requires compliance to Naming and Identifier Rules (NASA NIR)
  2. needs ontologies for vocabulary management and translations



# Thank You



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## Some References

